Prosperity, Consumption, and the Environmental Kuznets Curve: Implications for Forest Conservation

Julianne H Mills

Department of Evolution, Ecology and Organismal Biology, The Ohio State University,

300 Aronoff Laboratory, 318 W. 12th Ave., Columbus, OH, 43210, USA

Abstract

Many conservationists contend that economic growth and conservation are incompatible goals. Others contest this viewpoint, arguing that wealthier countries have the luxury of investing more heavily in conservation. Under this assumption, one might expect a *U*-shaped relationship between per capita wealth and the proportion of a country's forest that is preserved over time. This relationship, called the environmental Kuznets curve (EKC), predicts the following: as per capita income increases, measures of environmental health should first decrease, then rise again after a certain point, such that the richest nation-states should have superior environmental health.

Previously, I examined the evidence for this EKC among 35 tropical forest countries. To do so, I introduced the use of quantile regression and spatial filtering, addressing problems of heteroskedasticity and spatial autocorrelation common to EKC analyses. The new application of these methods to EKC analysis revealed some evidence to suggest the presence of an EKC—that is, rich countries did appear to protect a greater proportion of their forests, a proxy measure for biodiversity. However, a closer examination of conservation practices and environmental indicators within those countries that drove initial support suggests that wealth is not a reliable indicator of improved conservation practice. I show that this relationship is driven by differences between countries, in particular, their habits of resource production and consumption.

Here, I build upon the prior analysis, explicitly incorporating consumption of forest products through the use of production, import, and export data. I perform two separate analyses, one which incorporates all forest products (including wood used for fuel) and one which excludes fuelwood. Because low income countries use more fuelwood than any other group, its inclusion reveals consumption-driven losses at both income extremes. However, when fuel is excluded, all evidence that being rich promotes conservation is eliminated. Rich countries may practice preservation within their borders, but they appropriate resources from poorer countries to fuel their consumption.

These findings suggest, on one hand, that increasing prosperity may play a key role in promoting conservation, as alleviation of poverty would decrease the reliance on fuelwood for heating and cooking. Conversely, unhindered economic growth increases consumption at the expense of global conservation. Taken together, these findings have significant implications for both economic and conservation policies worldwide. Simple application of the EKC theory, which suggests constant economic growth as the best practice for conservation, is clearly unwarranted. On the contrary, these findings suggest that initial support for growth and poverty alleviation in low income countries might best be matched by policies which acknowledge limits to growth and strive for steady state economies amongst high income countries.

Introduction

Economists have long championed economic growth as the cure for a multitude of global challenges, including any number of environmental issues, from pollution to the biodiversity crisis (Beckerman 1992; Weizsäcker 1997). Quantitatively, this concept has been formalized in the environmental Kuznets curve hypothesis (EKC). Based on Simon Kuznets' study of income inequality (Kuznets 1955), the EKC was adapted to environmental applications by Grossman & Krueger (1991) nearly two decades ago and has been widely tested and debated ever since. The basic premise of the EKC is simple. The theory predicts an inverted *u*-shaped curve: environmental degradation is low when income is low, increases exponentially with increasing wealth, but drops off again after income rises past a certain turning point. The logic behind this model of environmental recovery is that wealth implies a degree of latitude; once a certain level of wealth is attained, people become free to prioritize and invest in the environment.

The evidence in support of the EKC, however, has been equivocal at best. Though a number of studies have demonstrated the presence of EKCs (Cavlovic et al. 2000; Grossman & Krueger 1991; Panayotou 1993), perhaps as many have shown results suggesting the opposite (Clausen & York 2008; Cropper & Griffiths 1994). Even when support is found, that support is limited to situations in which the environmental degradation is reversible; the EKC is not broadly applicable across all environmental indicators. Moreover, many scientists are already proclaiming that, as a useful theory, the EKC's lifespan is spent. Stern (2004) argues that the relationship is built upon flimsy statistical foundations, while Czech (2008) makes an even more foundational argument against the EKC, arguing that there is a *fundamental* conflict between economic growth and conservation, one which is rooted in the principles of thermodynamics and the physical limits to growth. Nevertheless, the policy community still implements the EKC as a tool in shaping the future of economics and development (Czech 2008; Stern 2004). Moreover, evidence in support of the EKC suggests that, whether the relationship is valid or not, rich countries often *appear* to be exhibiting improved environmental quality. Exploring the mechanisms behind this support is thus a crucial next step in understanding the nature of how economic prosperity (and aggregate economic growth) relates to environmental quality.

In order to investigate the possibility that apparent evidence in support of the EKC may be misleading, I take as a starting point the relationship between per capita wealth and biodiversity, examined by Mills & Waite (2009). They reveal some evidence to suggest the presence of an EKC. That is, rich countries did appear to protect a greater proportion of their forests, a proxy measure for biodiversity. However, Mills & Waite (2009) argue that this support is deceptive; closer examination of conservation practices and environmental indicators within those countries that drove the initial support suggested that wealth was not a reliable indicator of improved conservation practice. I explore this illusory support more fully, testing the hypothesis that apparent support for an EKC for forest conservation and biodiversity may be an artifact of global trade practices and consumption patterns.

Methods

Income and forest area data. I included in the dataset every country for which all data were available, resulting in a total of 88 countries across seven regions. For each country, I constructed a time series spanning the period 1972 to 1992 (though some countries' time series end earlier due to data availability). I used logged real GDP per capita in constant dollars (chain index, 1985 international prices) (Heston et al. 2002) as the measure of income. Forest area estimates, *F* (hectares), came from the FAO Production Yearbooks (1972-1994).

Incorporating consumption. Using data from the FAO ForesSTAT database, I calculated two measures of forest product consumption for each country: $CONS_{NF}$, which excludes wood used for fuel, and $CONS_F$, which includes fuelwood. I assumed that, Consumption = Production + Imports – Exports. To calculate $CONS_{NF}$, I considered production to be production of industrial roundwood and imports and exports to be the sum of import and export values for each of the following: industrial roundwood, paper and paperboard, sawnwood, wood pulp, and wood-based panels (all categories refer to the FAO ForesSTAT database). For $CONS_F$, I added fuelwood values to each term.

For each country, I also determined a hectare conversion factor, *H,* which is equivalent to a country's annual timber production (m^3/yr) divided by the area of forest harvested in that country annually (ha/yr) (data from Sohngen & Tennity 2004). As such, *H* is essentially a measure of the efficiency of forest product extraction. I used this conversion factor to relate consumption back to forest area, creating an adjusted forest estimate that predicts the amount of forest area I would expect each country to have in a given year if all the forest products they consumed were produced on their own lands (at their specific rate of harvest efficiency). I assumed that FAO forest area values already reflected forest loss due to a country's forest product production. I thus used *excess* consumption, *E*, defined simply as a country's total consumption less what they produce in-country (for either $CONS_{NF}$ or $CONS_F$), to create estimates that represent the expected forest area of country *i* in year *t* after accounting for the entirety of that country's consumption. I defined this consumption-adjusted forest area, *CaF, as*: $CaF(i,t) = F(i,t) - \left(\frac{E}{H}\right)$. For those countries and years where *E* is positive (consumption exceeds production), *CaF* is less than *F*, indicating that if those countries held responsible for producing all the forest products they consume, they would have less forest than actually exists.

Where E is negative (indicating that production exceeds consumption), CaF is greater than F. Such countries would have more forests if they were harvesting wood to fill only their own needs; at least some portion of their forest loss is driven by the others countries' consumption.

For each consumption measure (with or without fuelwood), I evaluated three metrics to make inferences about the role consumption plays in determining the relationship between per capita wealth and forest conservation: 1) excess consumption (E), which distinguishes between countries who act as net exporters and those who act as net importers; 2) raw gain or loss of forest hectarage ($CaF_{(i,t)}-F_{(i,t)}$), which describes the crude amount of forest involved in each adjusted estimate; and 3) extra proportional gain or loss of forests (due to consumption) $[(CaF_{(\mathrm{i,t})}/F_{(\mathrm{i,1972})})-(F_{(\mathrm{i,t})}/F_{(\mathrm{i,1972})})]$, which accounts for differences in size among countries by converting raw areas to a proportion of the baseline (1972) forest area. To make comparisons across income groups, I divided the dataset into four income categories using the World Bank's 1989 income classifications: low income (per capita GDP less than \$545), lower-middle income (per capita GDP between \$545 and \$2200), upper-middle income (per capita GDP between \$2200 and \$6000), and high income (per capita GDP greater than \$6000) (World Bank 1990).

I modeled each metric using a general linear model (GLM). Preliminary analysis revealed that a simple model, including just country specific fixed effects, GDP, and forest area, exhibited the best fit of any GLM model (r^2=0.741). However, as the intent of this study was to elucidate the specific differences between countries which drive the relationship between income and conservation, inclusion of country effects is detrimental, as it subsumes, and therefore masks, the effects of specific drivers. Thus, in order to examine these specific drivers, I built a model that treats country-years as the sampling unit, excludes country effects (except as incorporated into errors) and instead incorporates two fixed effects: income group and region, and eight covariates: GDP, forest area, latitude, population density, a scaled democracy value, and three spatial covariates (produced using the Borcard-Legendre Principal Coordinates of Neighbor Matrices technique of spatial filtering to account for spatial autocorrelation amongst countries (Borcard & Legendre 2002). Finally, I performed pairwise comparisons of the models' estimated marginal means to identify significant differences amongst income groups.

Results

Tallies of per capita wood product consumption per country reveal that when fuelwood is not included, consumption increases with increasing per capita GDP (Fig. 1.) Including fuelwood muddles this pattern (Fig. 2). However, excess consumption, that is, consumption beyond what a country produces, is significantly greater in high income countries than in any other group (Table 1); this holds true for both consumption counts: with and without fuel.

Consumption adjusted forest areas. When forest areas are adjusted to account for (non-fuel) wood product consumption, rather than accounting only for actual forest loss due to harvest for domestic production, rich countries undergo the largest (negative) adjustment (Table 1). The difference in raw hectarage between actual and adjusted forest areas decreases with increasing income; high income countries lose significantly more hectarage than any other group ($p<.01$). That is, high income countries spare their own forests, but consumption-based accounting reveals that they do so while consuming wood products produced from the forests of other countries. Similar patterns are seen for proportional forest loss. When these losses are related back to the 1972 forest area for each country, consumption-based accounting estimates that an extra loss of 3.5% of high income countries' baseline forests would be required to account for excess consumption that has been supplied by imported products over the span of the study (1972-1992;

Fig. 3). This loss is significantly greater than that estimated for lower-middle (.4%) or upper-middle income countries (1.2%); the difference between high and low income countries is non-significant (1.8% loss; but note that p=.061). In hectares, given that the high income group also happens to contain several of the largest countries in the dataset (with correspondingly large average forest areas, on the order of 155-350% larger than poorer groups), a loss of 3.5% translates to an extra loss of 2,360,000 hectares per country, compared to 848,000 hectares, 102,000 hectares, and 599,000 hectares for each of the low, lower-middle, and upper-middle income countries.

Including fuelwood yields results that differ in several notable ways from the relationships described above (Table 1). Low income countries are no longer credited with gains in raw hectarage. Instead they experience losses, and these losses are not significantly different from those incurred in the high income group. Further, inclusion of fuelwood amounts to additional proportional losses of baseline forests in the low income group, making the losses incurred by high and low income groups statistically indistinguishable (p=.340 as opposed to the tenuously non-significant relationship observed above).

Discussion

Consumption Eliminates Support for the EKC. The idea that trade and consumption may play a critical role in EKC analyses is not new. Rothman (1998) summarizes the case for consumption based approaches, arguing that what wealth really bestows is the ability of the wealthy to externalize the damages incurred by their consumption, thus creating apparent improvements in environmental indicators. Notably, however, nearly all of the studies specifically examining the effects of trade seem to have focused on pollution, not resource stocks. In terms of forests, in particular, the literature has largely been limited to ethical discussions of forest policy choices (is it better to reduce demand, substitute other products in favor of wood, or import wood from other countries; Berlik *et al*. 2002; Dekker-Robertson & Libby 1998) and limited case studies (Berlik *et al.* 2002; Mayer *et al.* 2005; Mayer *et al.* 2006).

This study is the first to empirically examine the effects of consumption on forest conservation across a broad spectrum of countries. Results indicate that incorporation of consumption eliminates all evidence in support of an EKC. Rather than perform better due to increased fiscal freedom, the high-income countries in this study performed worse than the other groups. The reasons for these trends are readily apparent when one considers the metric of excess consumption. High-income countries are the only group which consume, on average, more wood products than they produce. This is a prime example of weak (economic) sustainability. High-income countries substitute external resources for internal ones, allowing them to create the illusion of sustainability within their borders while simultaneously contributing to the drawdown of natural capital worldwide.

Technological Efficiency: Panacea or Pandemic? Many have argued that eco-efficiency and eco technologies are the key, both to permitting continued growth amongst the rich, and to allowing poverty stricken nations to join the ranks of high development without raising the bar of consumption (too much) (Myers 2000; Pulliam & O'Malley 1996). The findings of this study, on the other hand, suggest that, for conservation of forests and their coincident biodiversity, the truth is not so simple. The relationship between consumption (without fuelwood) and per capita GDP is one of exponential growth with increasing income (Figure 1). This comes as no surprise, as the expansion of consumption has often been noted as a serious consequence of affluence (Dietz *et al.* 2007; Hails *et al.* 2006; Myers 2000; Myers & Kent 2003). The argument of economics, however, is that this sort of growth is inherently good, and that the potential ill-effects which might accompany it are mitigated by continual improvements in technology, effectively eradicating limits to growth. In the case of the consumption-income relationship, then, one might argue that the obvious increases in consumption observed with affluence are balanced out by the vastly more efficient technologies exhibited by affluent societies.

By including a measure of the harvest efficiency (*H*) of each country in my consumption calculations, I test one aspect of this notion. While the data show that rich countries do, in fact, tend to exhibit exceptionally high levels of technological efficiency, harvesting dramatically more wood from each hectare of land than their poorer counterparts (Switzerland tops the list at $485m^3$/ha, Chad is at the bottom with $0.55m^3$/ha, and high income countries exhibit average efficiency levels that are significantly higher than low or lower-middle income groups $p<0.05$), the data indicate that these countries are nevertheless responsible for more consumption-driven forest loss than any of the poorer groups.

Fuelwood and Poverty. The one area in which technology may provide an advantage is in the realm of energy supply. When fuel is included in estimates of forest consumption, the average low-income country's wood consumption increases 1427% (as compared to 17% for high income countries, 237% for upper-middle countries, and 1255% for lower-middle income countries) (Figures 1 and 2). It is likely that these percentages are conservative, as fuelwood is often harvested as part of the informal economy (and potentially even illegally obtained, e.g. through encroachment on protected lands [van Kempen et al. 2009; Robbins et al. 2006]), particularly amongst the poorest of the poor. Nevertheless, it should be noted that, despite this 14-fold increase, including fuel in total consumption merely levels the playing field, eliminating rather than reversing the consumption-income relationship observed when fuel was excluded.

Replacing the use of wood fuel for cooking and heating will necessarily entail an alleviation of poverty, making this a prime policy objective for relieving consumption pressure on global forests from the low-income end, and suggesting at least one instance where poverty reduction and conservation may be readily compatible goals (Adams et al. 2004). However, reduced poverty brings with it a slew of attendant detrimental effects related to increased consumption (Myers & Kent 2003; Rothman 1998), and, given current trends, there is little reason to expect that today's developing countries will choose to forego increased consumption as they become more affluent and more developed (as of 2003, Cuba was the only country to exhibit both high human development *and* an ecological footprint below fair earthshare (Hails *et al*. 2006). Neither is it particularly reasonable to expect this, given the consumptive habits of already developed nations. Working downward, from the high-income end of the wealth spectrum, a different prescription becomes apparent: consumption must be reduced.

Trickle-down Economics Re-envisioned. Naturally, reducing consumption is clearly far easier said than done; it will require a wholesale change in the direction of economic thinking and individual preferences. Nonetheless, this study joins a growing body of scientific work in arguing that such a move is no less than a necessity if we intend to conserve our limited natural capital. Just as important as recognizing the need for change is determining how to pursue it. I posit that two key ideas may be instrumental in deliberations on this directive: 1) Responsible consumption should be place-based. 2) Wealth, as we know it, must be redefined.

As several authors have pointed out, free trade enables countries to export environmental damage to places outside their borders, and to export with it any awareness of, or responsibility for, the damages incurred (Berlik et al. 2002; Dekker-Robertson & Libby 1998; Mayer et al. 2005, 2006; Muradian & Martinez-Alier 2001). Responsible consumption, then, may start with domestic production. Policy makers should reexamine the benefits of regulation and move toward policies which promote self-sufficiency, that is, living off of the biocapacity available within one's own country, rather than absorbing extra capacity from others. Critics may argue that such a move would be an injustice to the poor, making it more difficult for them to increase their wealth and thereby escape poverty. While this may be accurate in the short run, the long term effects would be to curb the export of natural resources from low income countries, leaving them with more natural capital on which to build a (strongly) sustainable future.

In conjunction with such a move comes the necessity for a new formulation of wealth. Arguments have long been made that GDP falls far short in terms of describing human well-being, and a variety of indicators have been proposed to redefine the concept of wealth. Such indicators have shown that while GDP nearly doubled over the past several decades, progress has remained stagnant, and countries with higher GDP tend to experience less satisfaction per unit of consumption (NEF 2006; Talberth et al. 2007). Conflating progress with economic growth thus fails to achieve valuable progress while also endangering ecological stability.

Adoption of the view that well-being is more important than material wealth would free policy makers from all nations to address pressing human and ecological concerns, rather than focusing on continued growth. Such a stance would address not only the need for decreased consumption from the top-down, but also the desire, and indeed profound human right, for increased development from the bottom-up. Finally, in tandem with place-based policies, re-envisioning wealth would provide a framework in which human society might work *within* ecological limits to creatively circumvent the conflict which pits growth against the environment, thereby encouraging both progress *and* the strong, ecologically-based sustainability that will carry us into the future.

Figure 1. Per capita consumption of wood products (excluding fuel wood), $CONS_{NF}$, as a function of per capita GDP. Each country's time series (1972-1992) is denoted by a unique color and symbol.

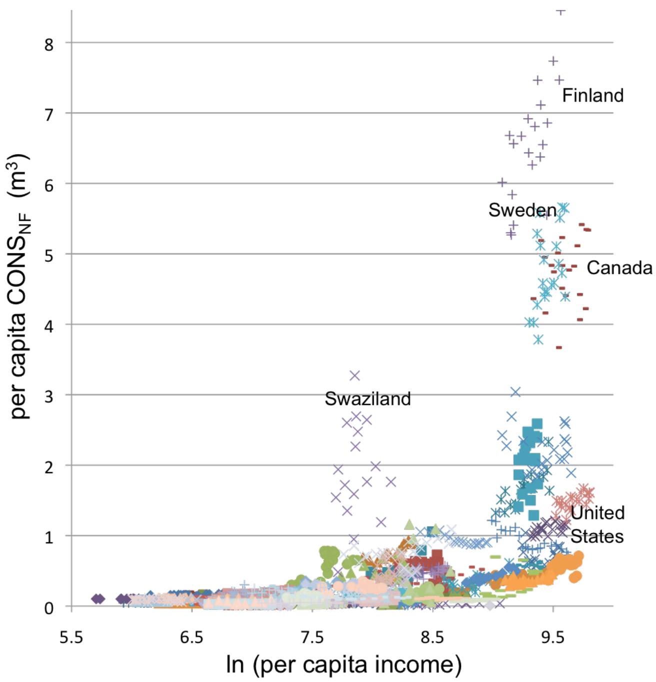

Figure 2. Per capita consumption of wood products (including fuel), $CONS_F$, as a function of per capita GDP. Each country's time series (1972-1992) is denoted by a unique color and symbol.

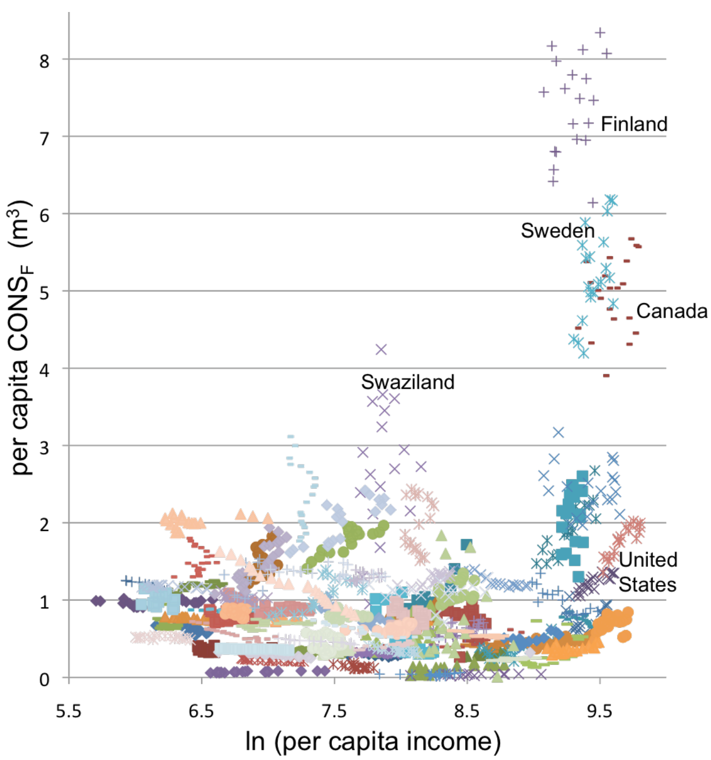

Figure 3. Excess gain (positive values) or loss (negative values) of forest area attributable to countries as a result of accounting for consumption of forest products. Values are relative to extant forest area in the base year, 1972. Vertical bars divide the x-axis into four income groups from left to right: low, lower-middle, upper-middle, and high. Horizontal bars indicate observed means for each group.

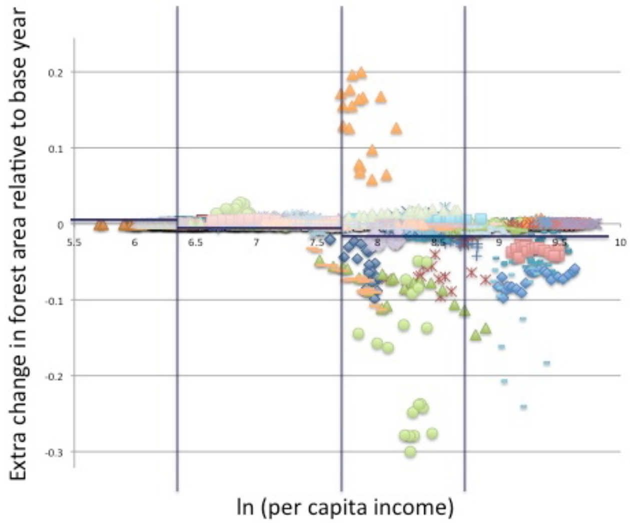

Table 1. Income-dependent differences in the impact of wood product consumption, both including and excluding fuelwood. Estimated marginal means and significance (as compared to high income countries) are presented for three metrics of consumption-based accounting. ** indicates significance at p<.01

		Income Group (n)	Low (104)	Lower-Mid (707)	Upper-Mid (622)	High (359)
Excludes Fuelwood	Excess consumption (million m^3)	Estimated marginal mean	-5.390	-6.130	-1.760	5.690
		Significance relative to high income group	0.000**	0.000**	0.000**	N/A
	Raw hectare difference (1000 hectares)	Estimated marginal mean	92.100	119.510	-13.450	-133.800
		Significance relative to high income group	0.000**	0.000**	0.000**	N/A
	Extra forest loss relative to base year (%)	Estimated marginal mean	1.80	0.40	1.20	3.50
		Significance relative to high income group	0.061	0.000**	0.000**	N/A
Includes Fuelwood	Excess consumption (million m^3)	Estimated marginal mean	-4.750	-6.070	-1.590	5.480
		Significance relative to high income group	0.000**	0.000**	0.000**	N/A
	Raw hectare difference (1000 hectares)	Estimated marginal mean	-4.030	109.600	-39.410	-94.530
		Significance relative to high income group	0.180	0.000**	0.081	N/A
	Extra forest loss relative to base year (%)	Estimated marginal mean	2.40	0.50	1.30	3.30
		Significance relative to high income group	0.340	0.000**	0.000**	N/A

References

Adams, W.M., Aveling, R., Brockington, D., Dickson, B., Elliott, J., Hutton, J., Roe, D., Vira, B., Wolmer, W., 2004. Biodiversity conservation and the eradication of poverty. Science, 306:1146-1149.

Beckerman, W., 1992. Economic growth and the environment: Whose growth? Whose environment? World Development, 20:481-496.

Berlik, M.M., Kittredge, D.B., Foster, D.R., 2002. The illusion of preservation: a global environmental argument for the local production of natural resources. Journal of Biogeography, 29:1557-1568.

Borcard, D., P. Legendre. 2002. All-scale spatial analysis of ecological data by means of principal coordinates of neighbour matrices. Ecological Modelling, 153:51-68.

Cavlovic, T., Baker, K.H., Berrens, R.P., Gawande, K., 2000. A meta-analysis of Kuznets curve studies. Agricultural and Resource Economics Review, 29:32-42.

Clausen, R., York, R., 2008. Global biodiversity decline of marine and freshwater fish: a cross-national analysis of economic, demographic, and ecological influences. Social Science Research, 37:1310-1320.

Cropper, M., Griffiths, C., 1994. The interaction of population growth and environmental quality. American Economic Review, 84:250-254.

Czech, B., 2008. Prospects for reconciling the conflict between economic growth and biodiversity conservation with technological progress. Conservation Biology, 22(6): 1389-1398.

Dekker-Robertson, D.L., Libby, W.J., 1998. American forest policy—global ethical tradeoffs. Bioscience, 48(6):471-477.

Dietz, T., Rosa, E.A., York, R., 2007. Driving the human ecological footprint. Frontiers in Ecology and the Environment, 5(1):13-18.

Grossman, G.M., Krueger, A.B., 1991. Environmental impacts of a North American Free Trade Agreement. National Bureau of Economic Research Working Paper 3914, NBER, Cambridge, MA.

Hails, C., Loh, J., Goldfinger, S., editors, 2006. Living Planet Report 2006. World Wildlife Fund.

Hails, C., Humphrey, S., Loh, J., Goldfinger, S., editors, 2008. Living Planet Report 2008. World Wildlife Fund.

Heston, A., Summers, R., Aten, B., 2002. Penn World Table Version 5.6. Center for International Comparisons at the University of Pennsylvania (CICUP).

Kuznets, S., 1955. Economic growth and income inequality. American Economic Review, 45:1-28.

Mayer, A.L., Kauppi, P.E., Angelstam, P.K., Zhang, Y., Tikka, P.M., 2005. Importing timber, exporting ecological impact. Science, 308:359-360.

Mayer, A.L., Kauppi, P.E., Tikka, P.M., Angelstam, P.K., 2006. Conservation implications of exporting domestic wood harvest to neighboring countries. Environmental Science and Policy, 9:228-236.

Mills, J.H., Waite, T.A., 2009. Economic prosperity, biodiversity conservation, and the environmental Kuznets curve. Ecological Economics, doi:10.1016/j.ecolecon.2009.01.017

Muradian, R., Martinez-Alier, J., 2001. Trade and the environment: from a 'Southern' perspective. Ecological Economics, 36:281-297.

Myers, N., 2000. Sustainable consumption. Science, 287:2419-2419.

Myers, N., Kent, J., 2003. New consumers: the influence of affluence on the environment. Proceedings of the National Academy of Sciences of the USA, 100(8):4963-4938.

NEF (New Economics Foundation), 2006. The un-happy planet index: an index of human well-being and environmental impact. The New Economics Foundation.

Panayotou, T., 1993. Empirical tests and policy analysis of environmental degradation at different stages of economic development. Technology and Employment Programme working paper WP238, International Labor Office, Geneva.

Pulliam, R.H., O'Malley, R., 1996. Economic policies should help achieve economic goals. Ecological Applications, 6(1):21-22.

Robbins, P., McSweeney, K., Waite, T., Rice, J., 2006. Even conservation rules are made to be broken: Implications for biodiversity. Environmental Management, 37(2): 162-169.

Rothman, D.S., 1998. Environmental Kuznets curves—real progress or passing the buck? A case for consumption-based approaches. Ecological Economics, 25:177-194.

Sohngen, B., Tennity, C., 2004. Country Specific Global Forest Data Set V.1. Mimeo. Dept. of Agr., Env., and Dev. Economics, Ohio State University.

Stern, D.I., 2004. The rise and fall of the environmental Kuznets curve. World Development, 32(8):1419-1439.

Talberth, J., Cobb, C., Slattery, N., 2007. The genuine progress indicator 2006: a tool for sustainable development. Redefining Progress.

van Kempen, L., Muradian, R., Sandóval, C., Castañeda, J.-P., 2009. Too poor to be green consumers? A field experiment on revealed preferences for firewood in rural Guatemala. Ecological Economics, doi:10.1016/j.ecolecon.2009.02.014

Weizsäcker, E.U.v., Lovins, A.B., Lovins, L.H., 1997. Factor Four: Doubling Wealth, Halving Resource Use—A Report to the Club of Rome. Earthscan Publications, Ltd., London.

World Bank Group, 1990. World development report 1990: poverty. Oxford University Press, Oxford.